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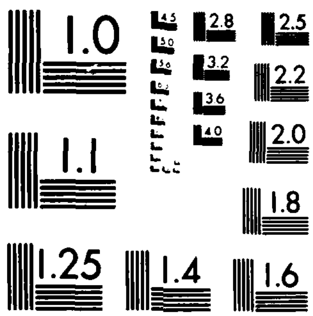
1.0
4.5
5.0
5.6
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1.4
1.6

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

RESULTS OF EXPERIMENTS ON CREATION OF CENTRAL CHANNEL OF LARGE DIAMETER IN ACTIVE ZONE OF BOILING WATER REACTOR

by

G.A. Batyzbekov, V.N. Okolovich, Zh.S. Takibayev

FOREIGN TECHNOLOGY DIVISION

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

GRAPHICS DISCLAIMER

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RESULTS OF EXPERIMENTS ON CREATION OF CENTRAL CHANNEL OF LARGE DIAMETER IN ACTIVE ZONE OF BOILING WATER REACTOR

G. A. Batyzbekov, V. N. Okolovich, Zh. S. Takibayev

Very significant in solving many critical problems in nuclear physics, radiation physics, metallurgy, and other fields of science which employ a nuclear reactor are the following factors:

1) the value of the neutron flux in the experimental channel;
2) the coefficient of nonuniformity of the neutral flux over the diameter of the channel;
3) the dimensions of the experimental channel;
4) the possibility of conducting long-term uninterrupted studies without reactor shut-down for the purpose of reloading fuel elements.

Projected experimental channels arranged on the periphery of the active zone of the reactor and in the water tank of the unit do not satisfy the above requirements. Moreover, the arrangement of the controls in the BWR reactor is not optimal and does not allow for the creation of sufficient reactance for long-term continuous measurements. Thus, experiments were undertaken for the purpose of determining the possibility of creating an experimental channel of a large diameter in the center of the active zone and a new variation for arrangement of the control and safety rod controls was tested. When such a channel is created the above reactor operating requirements can be satisfied to a significant degree under the condition that there is sufficient reserve reactance.

Presented in this study are the results of experiments to determine the critical mass of the reactor, the distribution of the thermal neutron flux over the diameter of the active zone for the case of a dry experimental channel, a "wet" (water-filled), and a physical mock-up of a 90 mm loop channel (4 fuel elements are taken from the center of the active zone). Also given is the critical mass of a 140 mm channel (7 fuel elements). The article also provides the efficiency values for the safety and control organs of the new control and safety rod arrangement (Figs. 1 and 2).

Nonstanadard start-up channels, including three pulse channels with SNM-11 counters and two current channels were used to determine the critical mass of the reactor. These made it possible to monitor the reactor in the deep subcritical mode and to provide protection from streams of neutrons and gamma-quanta. The plotting of three $1/N_n$ curves as a function of the number of fuel elements loaded into the active zone (N_n - reference speed of pulse channel) accompanied assembly of the critical reactor mass.

To determine the effectiveness of the safety and regulating controls an operational loading of the reactor sufficient to compensate for the "weight" of each safety and control rod, was carried out, and their effectiveness was determined by the power doubling period. In this case the known relationship between the riding-up time of the reactor T and reactance was employed (Zh. S. Takibuyev, G. A. Batyrbekov, V. N. Okolovich, L. A. Yurovskiy, 1968)

$$\rho = \frac{\lambda}{T} + \gamma \sum \frac{\beta_i}{1 + \lambda_i T},$$

where β_i and λ_i - represent the absolute yield of the i-th group of delayed neutron; λ - life of instantaneous neutrons; γ - effectiveness of delayed neutrons as compared to instantaneous.

Distributions of streams of thermal neutrons in the active zone were registered by the method of activating thin copper indicators (V. I. Golubev, V. I. Ivanov, M. N. Nikolayev, G. N. Smireukin, 1961) plays directly in the fuel elements. These were later counted on an

end-type β-counter. Employed in this case was the difference method (with and without cadmium) referred to the activity of a monitoring indicator immersed in a dry experimental channel on the periphery of the active zone.

Measurement data are shown in the Table in Figs. 1 and 2. Shown in Fig. 3 is the dependence $N_{k\rho} = f(n)$, where $N_{K\rho}$ is the critical reactor load in the number of fuel elements and n - the number of fuel elements taken from the center of the reactors' active zone.

From these measurements we learn that the tested variant for control and safety rod arrangement is significantly better than that previously projected. The obtained "weights" of the control rods make it possible to conduct continuous measurements over 1.5-2 months without shutting down the apparatus.

Of the distributions of thermal neutrons over the diameter of the reactor's active zone shown in Fig. 1 note the substantial increase in the flow of thermal neutrons in the center, water-filled, channel as compared to this value on the periphery of the active zone. For many experimental studies which require high radiation doses the creation of such a neutron trap represents a very valuable reactor improvement.

Thus the results of the experiments point to the advantage of creating a central channel of up to 140 mm which would expand experimental reactor possibilities and make it possible to conduct irradiation [studies] in streams significantly greater than the standard.

Currently studies related to improvement of the active zone are being conducted on the reactor. These will make it possible to employ central channels of both studied dimensions in experiments.

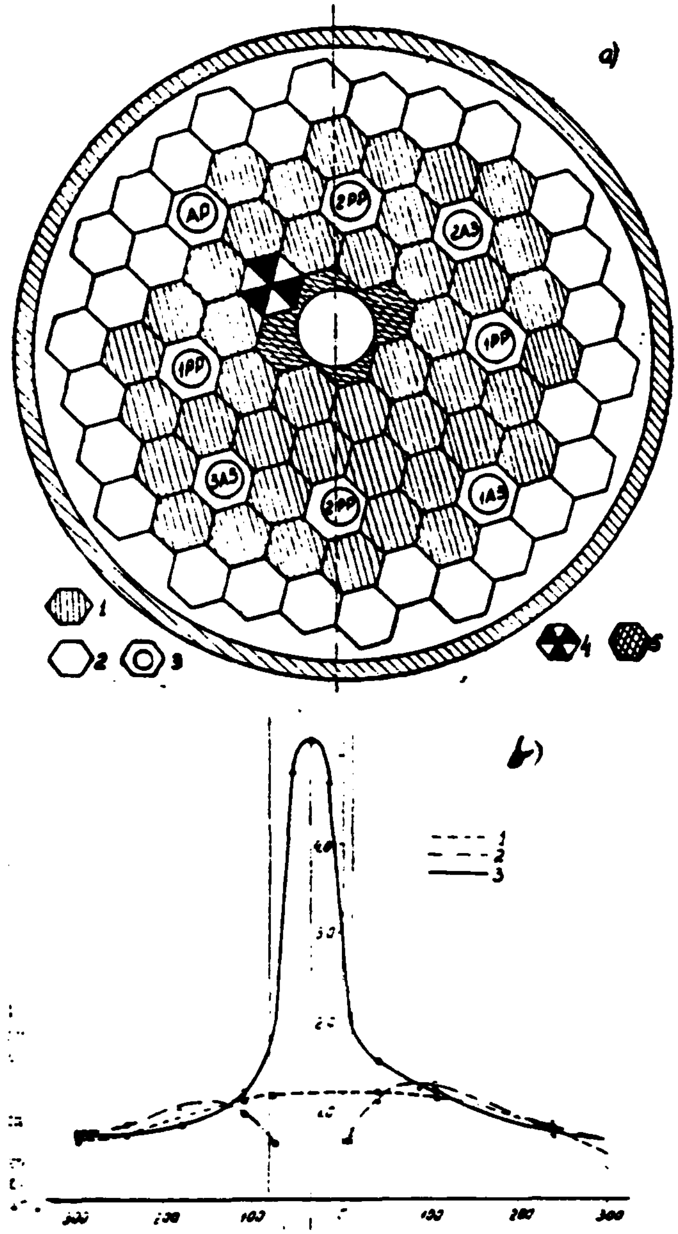

Fig. 1. a - cartogram representing loading of active zone for case of 90 mm central channel. 1 - type I fuel element; 2 - pump; 3 - safety and control organs; 4 - neutron source; 5 - pump with central channel; N_{kp} = 43 fuel elements; Σ(PP+AP) = 8.5%; ΣAS = 4.9%; b - distribution of thermal neutron flux over diameter of active zone (1 - air channel, 2 - physical mock-up of loop channel, 3 - "wet" channel).

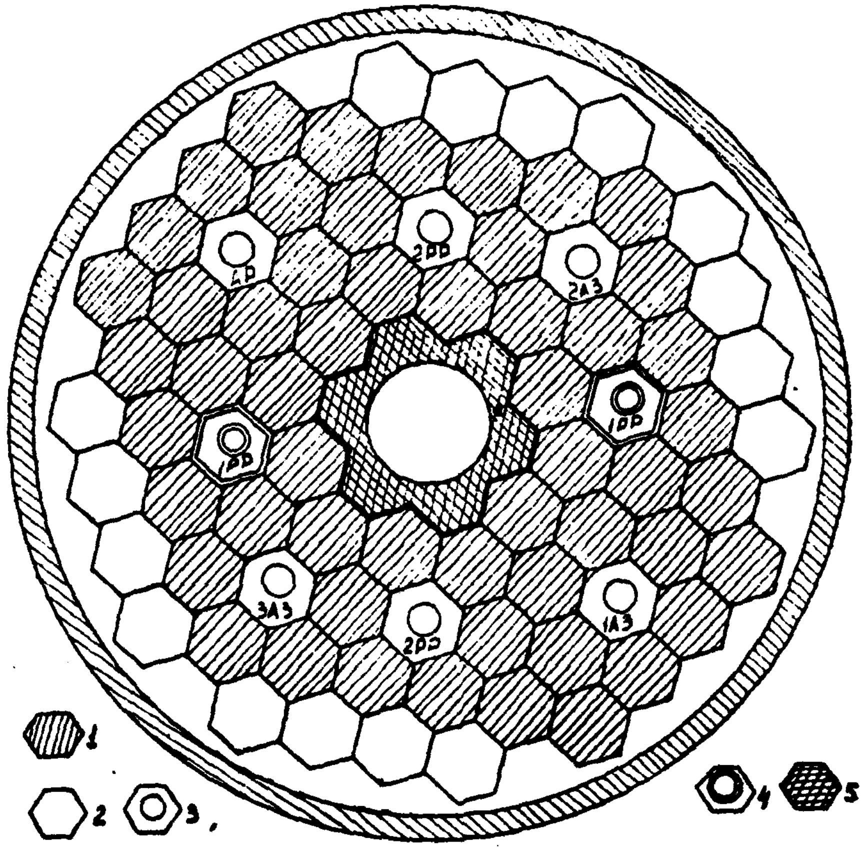

Fig. 2. Cartogram depicting loading of active zone for the case of 140 mm central channel. 1 - type I fuel element; 2 - pump; 3 - control and safety rods; 4 - control and safety rods with type II fuel element; 5 - pump with central channel.

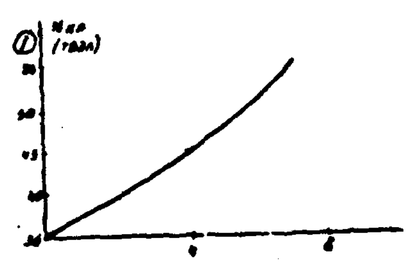

Fig. 3. Critical reactor load (N_{KP}) as function of the number of fuel element taken from the center of the active zone (n),

KEY: (1) Fuel element.

Данные экспериментов 1)		2) Проектный вариант	3) Канал 90 мм (4 ТВЭл)	4) Канал 140 мм (7 ТВЭл)
Критическая загрузка в числе ТВЭлов 5)		35	43	55
6) Эффективность органов, %	РР-1	0,6	2,9	2,5
	РР-2	4,3	2,6	2,3
	РР-3	—	2,6	2,3
	АР	0,3	0,4	0,4
	Σ РР 1+ +АР	5,7	8,5	7,5
	Σ АЗ	7,8	4,9	4,8
	Примечание 7)	Суммарный вес ручных регуляторов включает вес ПР 8)	Веса стержней приведены с воздушным каналом в центре активной зоны 9)	Веса стержней приведены с физмакетом петлевого канала в центре активной зоны 10)

KEY: (1) Data from experiments; (2) Project [standard] variant; (3) 90 mm channel (4 fuel elements); (4) 140 mm channel (7 fuel elements); (5) Critical load in number of fuel elements; (6) Effectiveness of controls, %; (7) Note; (8) Total weight of manual regulators includes weight of PR; (9) Weight of rods given with air channel in center of active zone; (10) Weights of rods given with physical mock-up of loop channel in center of active zone.

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